EIA STANDARD

Interface Between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange

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Engineering Department

ELECTRONIC INDUSTRIES ASSOCIATION

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INTERFACE BETWEEN DATA TERMINAL EQUIPMENT AND DATA COMMUNICATION EQUIPMENT EMPLOYING SERIAL BINARY DATA INTERCHANGE

(From EIA Standard RS-232-B and Standards Proposal No. 1012 formulated under the cognizance of EIA Subcommittee TR-30.2 on Interface.)

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SECTION ONE

1. SCOPE

1.1 This standard is applicable to the interconnection of data terminal equipment (DTE) and data communication equipment (DCE) employing serial binary* data interchange. It defines:

Section 2 – Electrical Signal Characteristics:–

Electrical characteristics of the interchange signals and associated circuitry.

Section 3 – Interface Mechanical Characteristics:–

Definition of the mechanical characteristics of the interface between the data terminal equipment and the data communication equipment.

Section 4 – Functional Description of Interchange Circuits:–

Functional description of a set of data, timing and control interchange circuits for use at a digital interface between data terminal equipment and data communication equipment.

Section 5 – Standard Interfaces for Selected Communication System Configurations:

Standard subsets of specific interchange circuits are defined for a specific group of data communication system applications.

In addition, the standard includes:

Section 6 – Recommendations and Explanatory Notes
Section 7 – Glossary of New Terms

1.2 This standard includes thirteen specific interface configurations intended to meet the needs of fifteen defined system applications. These configurations are identified by type, using alphabetic characters A through M. In addition, type Z has been reserved for applications not covered by types A through M, and where the configuration of interchange circuits is to be specified, in each case, by the supplier.

1.3 This standard is applicable for use at data signalling rates in the range from zero to a nominal upper limit of 20,000 bits per second.

1.4 This standard is applicable for the interchange of data, timing and control signals when used in conjunction with electronic equipment, each of which has a single common return (signal ground).

*See section 6.1.

that can be interconnected at the interface point. It does not apply where electrical isolation between equipment on opposite sides of the interface point is required.

1.5 This standard applies to both synchronous and nonsynchronous serial binary data communication systems.

1.6 This standard applies to all classes of data communication service, including:

1.6.1 Dedicated leased or private line service, either two wire or four wire. Consideration is given to both point-to-point and multipoint operation.

1.6.2 Switched network service, either two-wire or four-wire. Consideration is given to automatic answering of calls; however, this standard does not include all of the interchange circuits required for automatically originating a connection. (See EIA Standard RS-366 "Interface Between Data Terminal Equipment and Automatic Calling Equipment for Data Communication".)

1.7 The data set may include transmitting and receiving signal converters as well as control functions. Other functions, such as pulse regeneration, error control, etc., may or may not be provided. Equipment to provide these additional functions may be included in the data terminal equipment or in the data communication equipment, or it may be implemented as a separate unit interposed between the two.

1.7.1 When such additional functions are provided within the data terminal equipment or the data communication equipment, this interface standard shall apply only to the interchange circuits between the two classes of equipment.

1.7.2 When additional functions are provided in a separate unit inserted between the data terminal equipment and the data communication equipment, this standard shall apply to both sides (the interface with the data terminal equipment and the interface with the data communication equipment – See Section 3.1.1) of such separate unit.

1.8 This standard applies to all of the modes of operation afforded under the system configurations indicated in Section 5, Standard Interfaces for Selected Communication System Configurations.

SECTION TWO

2. ELECTRICAL SIGNAL CHARACTERISTICS

2.1 Figure 2.1, Interchange Equivalent Circuit, shows the electrical parameters which are specified in the subsequent paragraphs of this section. The equivalent circuit shown in Figure 2.1 is applicable to all interchange circuits regardless of the category (data, timing, or control) to which they belong. The equivalent circuit is independent of whether the driver is located in the data communication equipment and the terminator in the data terminal equipment or vice versa.

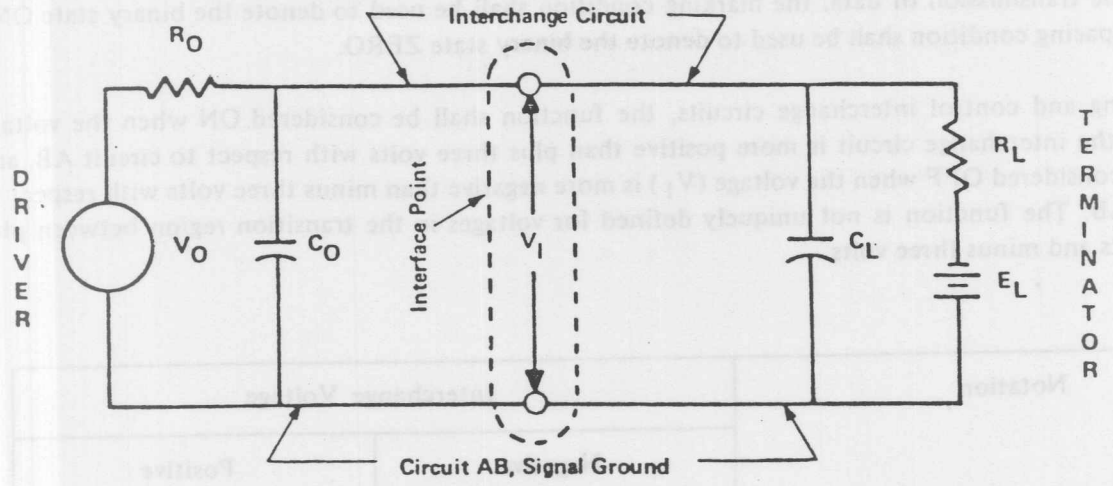

FIGURE 2.1 - INTERCHANGE EQUIVALENT CIRCUIT

V_O is the open-circuit driver voltage.

R_O is the driver internal dc resistance.

C_O is the total effective capacitance associated with the driver, measured at the interface point and including any cable to the interface point.

V_I is the voltage at the interface point.

C_L is the total effective capacitance associated with the terminator, measured at the interface point and including any cable to the interface point.

R_L is the terminator load dc resistance.

E_L is the open circuit terminator voltage (bias).

2.2 The driver on an interchange circuit shall be designed to withstand an open circuit, a short circuit between the conductor carrying that interchange circuit in the interconnecting cable and any other conductor in that cable, or any passive non-inductive load connected between that interchange circuit and any other interchange circuit including Circuit AB (Signal Ground), without sustaining damage to itself or its associated equipment. The terminator on an interchange circuit shall be designed to withstand any input signal within the 25 volt limit specified in section 2.6. (see Section 6.6).

2.3 For data interchange circuits, the signal shall be considered in the marking condition when the voltage (V_I) on the interchange circuit, measured at the interface point, is more negative than minus three volts with respect to Circuit AB (Signal Ground). The signal shall be considered in the spacing condition when the voltage (V_I) is more positive than plus three volts with respect to circuit AB (see 6.3). The region between plus three volts and minus three volts is defined as the transition region. The signal state is not uniquely defined when the voltage (V_I) is in this transition region.

During the transmission of data, the marking condition shall be used to denote the binary state ONE and the spacing condition shall be used to denote the binary state ZERO.

For timing and control interchange circuits, the function shall be considered ON when the voltage (V_1) on the interchange circuit is more positive than plus three volts with respect to circuit AB, and shall be considered OFF when the voltage (V_1) is more negative than minus three volts with respect to Circuit AB. The function is not uniquely defined for voltages in the transition region between plus three volts and minus three volts.

Notation	Interchange Voltage	
	Negative	Positive
Binary State	1	0
Signal Condition	Marking	Spacing
Function	OFF	ON

This specification neither implies nor precludes the use of terminator circuits which utilize hysteresis techniques to enhance their noise immunity; however, the requirements of section 2.5 must also be satisfied.

2.4 The load impedance (R_L and C_L) of the terminator side of an interchange circuit shall have a dc resistance (R_L) of not less than 3000 Ohms, measured with an applied voltage not greater than 25 volts in magnitude, nor more than 7000 Ohms, measured with an applied voltage of 3 to 25 volts in magnitude. The effective shunt capacitance (C_L) of the terminator side of an interchange circuit, measured at the interface point, shall not exceed 2500 picofarads. The reactive component of the load impedance shall not be inductive. The open circuit terminator voltage (E_L) shall not exceed 2 volts in magnitude. (See sections 6.4, 6.5, and 6.6).

2.5 The following interchange circuits, where implemented, shall be used to detect either a power-off condition in the equipment connected across the interface, or the disconnection of the interconnecting cable:

Circuit CA (Request to Send)

Circuit CC (Data Set Ready)

Circuit CD (Data Terminal Ready)

Circuit SCA (Secondary Request to Send)

The power-off source impedance of the driver side of these circuits shall not be less than 300 Ohms, measured with an applied voltage not greater than 2 volts in magnitude referenced to Circuit AB (Signal Ground). The terminator for these circuits shall interpret the power-off condition or the disconnection of the interconnecting cable as an OFF condition.

2.6 The open-circuit driver voltage (V_O) with respect to Circuit AB (Signal Ground) on any interchange circuit shall not exceed 25 volts in magnitude. The source impedance (R_O and C_O) of the driver side of an interchange circuit including any cable to the interface point is not specified; however, the combination of V_O and R_O shall be selected such that a short circuit between any two conductors (including ground) in the interconnecting cable shall not result in a current in excess of one-half ampere. Additionally, the driver design shall be such that, when the terminator load resistance (R_L) is in the range between 3000 Ohms and 7000 Ohms and the terminator open circuit voltage (E_L) is zero, the potential (V_1) at the interface point shall not be less than 5 volts nor more than 15 volts in magnitude (see section 6.5).

2.7 The characteristics of the interchange signals transmitted across the interface point, exclusive of external interference, shall conform to the limitations specified in this section. These limitations shall be satisfied at the interface point when the interchange circuit is terminated with any receiving circuit which meets the requirements given in Section 2.4. These limitations apply to all interchange signals (Data, Control and Timing) unless otherwise specified.

(1) All interchange signals entering into the transition region shall proceed through the transition region to the opposite signal state and shall not reenter the transition region until the next significant change of signal condition.

(2) There shall be no reversal of the direction of voltage change while the signal is in the transition region.

(3) For Control Interchange Circuits, the time required for the signal to pass through the transition region during a change in state shall not exceed one millisecond.

(4) For Data and Timing interchange Circuits, the time required for the signal to pass through the transition region shall not exceed one millisecond or four percent of the nominal duration of a signal element on that interchange circuit, whichever is the lesser.

(5) The maximum instantaneous rate of voltage change shall not exceed 30 volts per microsecond.

SECTION THREE

3. INTERFACE MECHANICAL CHARACTERISTICS

3.1 The interface between the data terminal equipment and data communication equipment is located at a pluggable connector signal interface point between the two equipments. The female connector shall be associated with, but not necessarily physically attached to the data communication equipment and should be mounted in a fixed position near the data terminal equipment. The use of an

extension cable on the data communication equipment is permitted. An extension cable with a male connector shall be provided with the data terminal equipment. The use of short cables (each less than approximately 50 feet or 15 meters) is recommended; however, longer cables are permissible, provided that the resulting load capacitance (C_L of Fig. 2.1), measured at the interface point and including the signal terminator, does not exceed 2500 picofarads. (See section 2.4 and 6.5.)

3.1.1 When additional functions are provided in a separate unit inserted between the data terminal equipment and the data communication equipment (See section 1.7), the female connector, as indicated above shall be associated with the side of this unit which interfaces with the data terminal equipment while the extension cable with the male connector shall be provided on the side which interfaces with the data communication equipment.

Pin Number	Circuit	Description
1	AA	Protective Ground
2	BA	Transmitted Data
3	BB	Received Data
4	CA	Request to Send
5	CB	Clear to Send
6	CC	Data Set Ready
7	AB	Signal Ground (Common Return)
8	CF	Received Line Signal Detector
9	–	(Reserved for Data Set Testing)
10	–	(Reserved for Data Set Testing)
11		Unassigned (See section 3.2)
12	SCF	Sec. Rec'd. Line Sig. Detector
13	SCB	Sec. Clear to Send
14	SBA	Secondary Transmitted Data
15	DB	Transmission Signal Element Timing (DCE Source)
16	SBB	Secondary Received Data
17	DD	Receiver Signal Element Timing (DCE Source)
18		Unassigned
19	SCA	Secondary Request to Send
20	CD	Data Terminal Ready
21	CG	Signal Quality Detector
22	CE	Ring Indicator
23	CH/CI	Data Signal Rate Selector (DTE/DCE Source)
24	DA	Transmit Signal Element Timing (DTE Source)
25		Unassigned

Figure 3.1

Interface Connector Pin Assignments

3.2 Pin Identification

3.2.1 Pin assignments listed in Figure 3.1 shall be used.

3.2.2 Pin assignments for circuits not specifically defined in section 4 (See section 4.1.1.) are to be made by mutual agreement. Preference should be given to the use of unassigned pins, but in the event that additional pins are required extreme caution should be taken in their selection.

SECTION FOUR

4. FUNCTIONAL DESCRIPTION OF INTERCHANGE CIRCUITS

4.1 General

This section defines the basic interchange circuits which apply, collectively, to all systems.

4.1.1 Additional interchange circuits not defined herein, or variations in the functions of the defined interchange circuits may be provided by mutual agreement. See sections 3.2.2. and 5.2.

4.2 Categories

Interchange circuits between data terminal equipment and data communication equipment fall into four general categories.

Ground or Common Return
Data Circuits
Control Circuits
Timing Circuits

4.2.1 A list of circuits showing category as well as equivalent C.C.I.T.T. identification in accordance with Recommendation V.24 is presented in Figure 4.1.

4.3 Signal Characteristics, General

4.3.1 Interchange circuits transferring data signals across the interface point shall hold marking (binary ONE) or spacing (binary ZERO) conditions for the total nominal duration of each signal element.

In synchronous systems using synchronous data communication equipment, distortion tolerances as specified in RS-334[1] shall apply. Acceptable distortion tolerances for data terminal equipment in synchronous and start-stop (i.e. asynchronous) systems using non-synchronous

[1] RS-334 "Signal Quality at Interface Between Data Processing Terminal Equipment and Synchronous Data Communication Equipment for Serial Data Transmission" - March 1967.

data communication equipment are under consideration for a future companion standard to RS-334.

4.3.2 Interchange circuits transferring timing signals across the interface point shall hold ON and OFF conditions for nominally equal periods of time, consistent with acceptable tolerances as specified in RS-334. During periods when timing information is not provided on a timing interchange circuit, this interchange circuit shall be clamped in the OFF condition.

4.3.3 Tolerances on the relationship between data and associated timing signals shall be in accordance with RS-334.

Interchange Circuit	C.C.I.T.T. Equivalent	Description	Gnd	Data		Control		Timing	
				From DCE	To DCE	From DCE	To DCE	From DCE	To DCE
AA	101	Protective Ground	X						
AB	102	Signal Ground/Common Return	X						
BA	103	Transmitted Data			X				
BB	104	Received Data		X					
CA	105	Request to Send					X		
CB	106	Clear to Send				X			
CC	107	Data Set Ready				X			
CD	108.2	Data Terminal Ready					X		
CE	125	Ring Indicator				X			
CF	109	Received Line Signal Detector				X			
CG	110	Signal Quality Detector				X			
CH	111	Data Signal Rate Selector (DTE)					X		
CI	112	Data Signal Rate Selector (DCE)				X			
DA	113	Transmitter Signal Element Timing (DTE)							X
DB	114	Transmitter Signal Element Timing (DCE)						X	
DD	115	Receiver Signal Element Timing (DCE)						X	
SBA	118	Secondary Transmitted Data			X				
SBB	119	Secondary Received Data		X					
SCA	120	Secondary Request to Send					X		
SCB	121	Secondary Clear to Send				X			
SCF	122	Secondary Rec'd Line Signal Detector				X			

Figure 4.1

Interchange Circuits by Category

4.4 Interchange Circuits

Circuit AA – Protective Ground (C.C.I.T.T. 101)
Direction: Not applicable

This conductor shall be electrically bonded to the machine or equipment frame. It may be further connected to external grounds as required by applicable regulations.

Circuit AB – Signal Ground or Common Return (C.C.I.T.T. 102)
Direction: Not applicable

This conductor establishes the common ground reference potential for all interchange circuits except Circuit AA (Protective Ground). Within the data communication equipment, this circuit shall be brought to one point, and it shall be possible to connect this point to Circuit AA by means of a wire strap inside the equipment. This wire strap can be connected or removed at installation, as may be required to meet applicable regulations or to minimize the introduction of noise into electronic circuitry.

Circuit BA – Transmitted Data (C.C.I.T.T. 103)
Direction: TO data communication equipment

Signals on this circuit are generated by the data terminal equipment and are transferred to the local transmitting signal converter for transmission of data to remote data terminal equipment.

The data terminal equipment shall hold Circuit BA (Transmitted Data) in marking condition during intervals between characters or words, and at all times when no data are being transmitted.

In all systems, the data terminal equipment shall not transmit data unless an ON condition is present on all of the following four circuits, where implemented.

1. Circuit CA (Request to Send)
2. Circuit CB (Clear to Send)
3. Circuit CC (Data Set Ready)
4. Circuit CD (Data Terminal Ready)

All data signals that are transmitted across the interface on interchange circuit BA (Transmitted Data) during the time an ON condition is maintained on all of the above four circuits, where implemented, shall be transmitted to the communication channel.

See Section 4.3, for signal characteristics.

Circuit BB – Received Data (C.C.I.T.T. 104)
Direction: FROM data communication equipment

Signals on this circuit are generated by the receiving signal converter in response to data signals received from remote data terminal equipment via the remote transmitting signal converter. Circuit BB

(Received Data) shall be held in the binary ONE (Marking) condition at all times when Circuit CF (Received Line Signal Detector) is in the OFF condition.

On a half duplex channel, Circuit BB shall be held in the Binary One (Marking) condition when Circuit CA (Request to Send) is in the ON condition and for a brief interval following the ON to OFF transition of Circuit CA to allow for the completion of transmission (See Circuit BA - Transmitted Data) and the decay of line reflections. See section 4.3 for signal characteristics.

Circuit CA – Request to Send (C.C.I.T.T. 105)
Direction: TO data communication equipment

This circuit is used to condition the local data communication equipment for data transmission and, on a half duplex channel, to control the direction of data transmission of the local data communication equipment.

On one way only channels or duplex channels, the ON condition maintains the data communication equipment in the transmit mode. The OFF condition maintains the data communication equipment in a non-transmit mode.

On a half duplex channel, the ON condition maintains the data communication equipment in the transmit mode and inhibits the receive mode. The OFF condition maintains the data communication equipment in the receive mode.

A transition from OFF to ON instructs the data communication equipment to enter the transmit code (see Section 6.8). The data communication equipment responds by taking such action as may be necessary and indicates completion of such actions by turning ON Circuit CB (Clear to Send), thereby indicating to the data terminal equipment that data may be transferred across the interface point on interchange Circuit BA (Transmitted Data).

A transition from ON to OFF instructs the data communication equipment to complete the transmission of all data which was previously transferred across the interface point on interchange Circuit BA and then assume a non-transmit mode or a receive mode as appropriate. The data communication equipment responds to this instruction by turning OFF Circuit CB (Clear to Send) when it is prepared to again respond to a subsequent ON condition of Circuit CA.

> *NOTE:* A non-transmit mode does not imply that all line signals have been removed from the communication channel. See section 6.8.

When Circuit CA is turned OFF, it shall not be turned ON again until Circuit CB has been turned OFF by the data communication equipment.

An ON condition is required on Circuit CA as well as on Circuit CB, Circuit CC (Data Set Ready) and, where implemented, Circuit CD (Data Terminal Ready) whenever the data terminal equipment transfers data across the interface on interchange Circuit BA.

It is permissible to turn Circuit CA ON at any time when Circuit CB is OFF regardless of the condition of any other interchange circuit.

Circuit CB – Clear to Send (C.C.I.T.T. 106)
Direction: FROM data communication equipment

Signals on this circuit are generated by the data communication equipment to indicate whether or not the data set is ready to transmit data.

The ON condition together with the ON condition on interchange circuits CA, CC and, where implemented, CD, is an indication to the data terminal equipment that signals presented on Circuit BA (Transmitted Data) will be transmitted to the communication channel.

The OFF condition is an indication to the data terminal equipment that it should not transfer data across the interface on interchange Circuit BA.

The ON condition of Circuit CB is a response to the occurrence of a simultaneous ON condition on Circuits CC (Data Set Ready) and Circuit CA (Request to Send), delayed as may be appropriate to the data communication equipment for establishing a data communication channel (including the removal of the MARK HOLD clamp from the Received Data interchange circuit of the remote data set) to a remote data terminal equipment.

Where Circuit CA (Request to Send) is not implemented in the data communication equipment with transmitting capability, Circuit CA shall be assumed to be in the ON condition at all times, and Circuit CB shall respond accordingly.

Circuit CC – Data Set Ready (C.C.I.T.T. 107)
Direction: FROM data communication equipment

Signals on this circuit are used to indicate the status of the local data set.

The ON condition on this circuit is presented to indicate that –

a) the local data communication equipment is connected to a communication channel ("OFF HOOK" in switched service),

AND b) the local data communication equipment is not in test (local or remote), talk (alternate voice) or dial* mode, (See section 6.10).

AND c) the local data communication equipment has completed, where applicable

1. any timing functions required by the switching system to complete call establishment, and

2. the transmission of any discreet answer tone, the duration of which is controlled solely by the local data set.

* The data communication equipment is considered to be in the dial mode when circuitry directly associated with the call origination function is connected to the communication channel. These functions include signalling to the central office (dialing) and monitoring the communication channel for call progress or answer back signals.

Where the local data communication equipment does not transmit an answer tone, or where the duration of the answer tone is controlled by some action of the remote data set, the ON condition is presented as soon as all the other above conditions (a, b, and c-1) are satisfied.

This circuit shall be used only to indicate the status of the local data set. The ON condition shall not be interpreted as either an indication that a communication channel has been established to a remote data station or the status of any remote station equipment.

The OFF condition shall appear at all other times and shall be an indication that the data terminal equipment is to disregard signals appearing on any other interchange circuit with the exception of Circuit CE (Ring Indicator). The OFF condition shall not impair the operation of Circuit CE or Circuit CD (Data Terminal Ready).

When the OFF condition occurs during the progress of a call before Circuit CD is turned OFF, the data terminal equipment shall interpret this as a lost or aborted connection and take action to terminate the call. Any subsequent ON condition on Circuit CC is to be considered a new call.

When the data set is used in conjunction with Automatic Calling Equipment, the OFF to ON transition of Circuit CC shall not be interpreted as an indication that the ACE has relinquished control of the communication channel to the data set. Indication of this is given on the appropriate lead in the ACE interface (see EIA Standard RS-366).

> *Note:* Attention is called to the fact that if a data call is interrupted by alternate voice communication, Circuit CC will be in the OFF condition during the time that voice communication is in progress. The transmission or reception of the signals required to condition the communication channel or data communication equipment in response to the ON condition of interchange Circuit CA (Request to Send) of the transmitting data terminal equipment will take place after Circuit CC comes ON, but prior to the ON condition on Circuit CB (Clear to Send) or Circuit CF (Received Line Signal Detector).

Circuit CD – Data Terminal Ready (C.C.I.T.T. 108.2)
Direction: To data communication equipment

Signals on this circuit are used to control switching of the data communication equipment to the communication channel. The ON condition prepares the data communication equipment to be connected to the communication channel and maintains the connection established by external means (e.g., manual call origination, manual answering or automatic call origination).

When the station is equipped for automatic answering of received calls and is in the automatic answering mode, connection to the line occurs only in response to a combination of a ringing signal and the ON condition of Circuit CD (Data Terminal Ready): however, the data terminal equipment is normally permitted to present the ON condition on Circuit CD whenever it is ready to transmit or receive data, except as indicated below.

The OFF condition causes the data communication equipment to be removed from the communication channel following the completion of any "in process" transmission. See Circuit BA (Transmitted Data). The OFF condition shall not disable the operation of Circuit CE (Ring Indicator).

In switched network applications, when circuit CD is turned OFF, it shall not be turned ON again until Circuit CC (Data Set Ready) is turned OFF by the data communication equipment.

Circuit CE – Ring Indicator (C.C.I.T.T. 125)
Direction: FROM data communication equipment

The ON condition of this circuit indicates that a ringing signal is being received on the communication channel.

The ON condition shall appear approximately coincident with the ON segment of the ringing cycle (during rings) on the communication channel.

The OFF condition shall be maintained during the OFF segment of the ringing cycle (between "rings") and at all other times when ringing is not being received. The operation of this circuit shall not be disabled by the OFF condition on Circuit CD (Data Terminal Ready).

Circuit CF – Received Line Signal Detector (C.C.I.T.T. 109)
Direction: FROM data communication equipment

The ON condition on this circuit is presented when the data communication equipment is receiving a signal which meets its suitability criteria. These criteria are established by the data communication equipment manufacturer.

The OFF condition indicates that no signal is being received or that the received signal is unsuitable for demodulation.

The OFF condition of Circuit CF (Received Line Signal Detector) shall cause Circuit BB (Received Data) to be clamped to the Binary One (Marking) condition.

The indications on this circuit shall follow the actual onset or loss of signal by appropriate guard delays.

On half duplex channels, Circuit CF is held in the OFF condition whenever Circuit CA (Request to Send) is in the ON condition and for a brief interval of time following the ON to OFF transition of Circuit CA. (See Circuit BB.)

Circuit CG – Signal Quality Detector (C.C.I.T.T. 110)
Direction: FROM data communication equipment

Signals on this circuit are used to indicate whether or not there is a high probability of an error in the received data.

An ON condition is maintained whenever there is no reason to believe that an error has occurred.

An OFF condition indicates that there is a high probability of an error. It may, in some instances, be used to call automatically for the retransmission of the previously transmitted data signal. Preferably the response of this circuit shall be such as to permit identification of individual questionable signal elements on Circuit BB (Received Data).

Circuit CH - Data Signal Rate Selector (DTE Source) (C.C.I.T.T. 111)
Direction: TO data communication equipment

Signals on this circuit are used to select between the two data signalling rates in the case of dual rate synchronous data sets or the two ranges of data signalling rates in the case of dual range non-synchronous data sets.

An ON condition shall select the higher data signalling rate or range of rates.

The rate of timing signals, if included in the interface, shall be controlled by this circuit as may be appropriate.

Circuit CI – Data Signal Rate Selector (DCE Source) (C.C.I.T.T. 112)
Direction: FROM data communication equipment

Signals on this circuit are used to select between the two data signalling rates in the case of dual rate synchronous data sets or the two ranges of data signalling rates in the case of dual range non-synchronous data sets.

An ON condition shall select the higher data signalling rate or range of rates.

The rate of timing signals, if included in the interface, shall be controlled by this circuit as may be appropriate.

Circuit DA – Transmitter Signal Element Timing (DTE Source) (C.C.I.T.T. 113)
Direction: TO data communication equipment

Signals on this circuit are used to provide the transmitting signal converter with signal element timing information.

The ON to OFF transition shall nominally indicate the center of each signal element on Circuit BA (Transmitted Data). When Circuit DA is implemented in the DTE, the DTE shall normally provide timing information on this circuit whenever the DTE is in a POWER ON condition. It is permissible for the DTE to withhold timing information on this circuit for short periods provided Circuit CA (Request to Send) is in the OFF condition. (For example, the temporary withholding of timing information may be necessary in performing maintenance tests within the DTE.)

Circuit DB Transmitter Signal Element Timing (DCE Source) (C.C.I.T.T. 114)
Direction: FROM data communication equipment

Signals on this circuit are used to provide the data terminal equipment with signal element timing information. The data terminal equipment shall provide a data signal on Circuit BA (Transmitted Data) in which the transitions between signal elements nominally occur at the time of the transitions from OFF to ON condition of the signal on Circuit DB. When Circuit DB is implemented in the DCE, the DCE shall normally provide timing information on this circuit whenever the DCE is in a POWER ON condition. It is permissible for the DCE to withhold timing information on this circuit for short periods provided Circuit CC (Data Set Ready) is in the OFF condition. (For example, the withholding of timing information may be necessary in performing maintenance tests within the DCE.)

Circuit DD – Receiver Signal Element Timing (DCE Source) (C.C.I.T.T. 115)
Direction: FROM data communication equipment.

Signals on this circuit are used to provide the data terminal equipment with received signal element timing information. The transition from ON to OFF condition shall nominally indicate the center of each signal element on Circuit BB (Received Data). Timing information on Circuit DD shall be provided at all times when Circuit CF (Received Line Signal Detector) is in the ON condition. It may, but need not be present following the ON to OFF transition of Circuit CF (See section 4.3.2).

Circuit SBA – Secondary Transmitted Data (C.C.I.T.T. 118)
Direction: TO data communication equipment

This circuit is equivalent to Circuit BA (Transmitted Data) except that it is used to transmit data via the secondary channel.

Signals on this circuit are generated by the data terminal equipment and are connected to the local secondary channel transmitting signal converter for transmission of data to remote data terminal equipment.

The data terminal equipment shall hold Circuit SBA (Secondary Transmitted Data) in marking condition during intervals between characters or words and at all times when no data are being transmitted.

In all systems, the data terminal equipment shall not transmit data on the secondary channel unless an ON condition is present on all of the following four circuits, where implemented:

1. Circuit SCA – Secondary Request to Send
2. Circuit SCB – Secondary Clear to Send
3. Circuit CC – Data Set Ready
4. Circuit CD – Data Terminal Ready

All data signals that are transmitted across the interface on interchange Circuit SBA during the time when the above conditions are satisfied shall be transmitted to the communication channel. See Section 4.3.

When the secondary channel is useable only for circuit assurance or to interrupt the flow of data in the primary channel (less than 10 Baud capability), Circuit SBA (Secondary Transmitted Data) is normally not provided, and the channel carrier is turned ON or OFF by means of Circuit SCA (Secondary Request to Send). Carrier OFF is interpreted as an "Interrupt" condition.

Circuit SBB – Secondary Received Data (C.C.I.T.T. 119)
Direction: FROM data communication equipment

This circuit is equivalent to Circuit BB (Received Data) except that it is used to receive data on the secondary channel.

When the secondary channel is useable only for circuit assurance or to interrupt the flow of data in the primary channel, Circuit SBB is normally not provided. See interchange Circuit SCF (Secondary Received Line Signal Detector).

Circuit SCA – Secondary Request to Send (C.C.I.T.T. 120)
Direction: TO data communication equipment

This circuit is equivalent to Circuit CA (Request to Send) except that it requests the establishment of the secondary channel instead of requesting the establishment of the primary data channel.

Where the secondary channel is used as a backward channel, the ON condition of Circuit CA (Request to Send) shall disable Circuit SCA and it shall not be possible to condition the secondary channel transmitting signal converter to transmit during any time interval when the primary channel transmitting signal converter is so conditioned. Where system considerations dictate that one or the other of the two channels be in transmit mode at all times but never both simultaneously, this can be accomplished by permanently applying an ON condition to Circuit SCA (Secondary Request to Send) and controlling both the primary and secondary channels, in complementary fashion, by means of Circuit CA (Request to Send). Alternatively, in this case; Circuit SCB need not be implemented in the interface.

When the secondary channel is useable only for circuit assurance or to interrupt the flow of data in the primary data channel, Circuit SCA shall serve to turn ON the secondary channel unmodulated carrier. The OFF condition of Circuit SCA shall turn OFF the secondary channel carrier and thereby signal an interrupt condition at the remote end of the communication channel.

Circuit SCB – Secondary Clear to Send (C.C.I.T.T. 121)
Direction: FROM data communication equipment.

This circuit is equivalent to Circuit CB (Clear to Send), except that it indicates the availability of the secondary channel instead of indicating the availability of the primary channel. This circuit is not provided where the secondary channel is useable only as a circuit assurance or an interrupt channel.

Circuit SCF – Secondary Received Line Signal Detector (C.C.I.T.T. 122)
Direction: FROM data communication equipment

This circuit is equivalent to Circuit CF (Received Line Signal Detector) except that it indicates the proper reception of the secondary channel line signal instead of indicating the proper reception of a primary channel received line signal.

Where the secondary channel is useable only as a circuit assurance or an interrupt channel (see Circuit SCA - Secondary Request to Send), Circuit SCF shall be used to indicate the circuit assurance status or to signal the interrupt. The ON condition shall indicate circuit assurance or a non-interrupt condition. The OFF condition shall indicate circuit failure (no assurance) or the interrupt condition.

SECTION FIVE

5. STANDARD INTERFACES FOR SELECTED COMMUNICATION SYSTEM CONFIGURATIONS

5.1 This section describes a selected set of data transmission configurations. For each of these configurations a standard set of interchange circuits (defined in section 4) is listed. (See section 6.2.)

5.1.1 Provision is made for additional data transmission configurations not defined herein. Interchange circuits for these applications must be specified separately, for each application, by the supplier.

5.2 Drivers shall be provided for every interchange circuit included in the standard interface. Terminators need not be provided for every interchange circuit included in the standard interface; however, the designer of the equipment which does not provide all of the specified terminators must be aware that any degradation in service due to his disregard of a standard interchange circuit is his responsibility.

In the interest of minimizing the number of different types of equipment, additional interchange circuits may be included in the design of a general unit capable of satisfying the requirements of several different applications.

5.2.1 For a given configuration, interchange circuits which are included in the standard list and for which drivers are provided, but which the manufacturer of equipment at the receiving side of the interface chooses not to use, shall be suitably terminated by means of a dummy load impedance in the equipment which normally provides the terminator. See Section 2.4.

5.2.2 Where interchange circuits not on the standard list are provided for a given configuration, the designer of this equipment must be prepared to find an open circuit on the other side of the interface, and the system shall not suffer degradation of the basic service.

Interference due to unterminated drivers in this category is the responsibility of the designer who includes these drivers.

Terminators shall not interfere with or degrade system performance as a result of open circuited input terminals.

5.3 Circuit configurations for which standard sets of interchange circuits are defined are listed in Figure 5.1.

5.4 The use of Circuit AA (Protective Ground) is optional. Where it is used, attention is called to the applicable Underwriters' regulation applying to wire size and color coding. Where it is not used, other provisions for grounding equipment frames should be made in accordance with good engineering practice.

5.5 The use of Circuit AB (Signal Ground) is mandatory in all systems. See section 1.4.

5.6 Secondary channels, where involved in the standard interfaces, are shown as Auxiliary Channels.

5.6.1 Where secondary channels are intended for use as backward channels, Circuit SCA (Secondary Request to Send) shall be interconnected with Circuit CA (Request to Send) within the data communication equipment and need not be brought out to the interface. See Section 4.4, Interchange Circuit SCA (Secondary Request to Send) for detailed information.

5.6.2 Where secondary channels are useable only for circuit assurance or to interrupt the flow of data in the primary channel, they transmit no actual data and depend only on the presence or absence of the secondary channel carrier. For this application only, Circuit SBA (Secondary Transmitted Data), SBB (Secondary Received Data) and SCB (Secondary Clear to Send) are not provided. Circuit SCA (Secondary Request to Send) turns secondary channel carrier ON and OFF as required and Circuit SCF (Secondary Received Line Signal Detector) recognizes its presence or absence. See definitions of Circuits SCA and SCF in Section 4.4 for details.

Data Transmission Configuration	Interface Type
Transmit Only	A
Transmit Only*	B
Receive Only	C
Half Duplex	D
Duplex*	D
Duplex	E
Primary Channel Transmit Only * / Secondary Channel Receive Only	F
Primary Channel Transmit Only / Secondary Channel Receive Only	H
Primary Channel Receive Only / Secondary Channel Transmit Only*	G
Primary Channel Receive Only / Secondary Channel Transmit Only	I
Primary Channel Transmit Only* / Half Duplex Secondary Channel	J
Primary Channel Receive Only / Half Duplex Secondary Channel	K
Half Duplex Primary Channel / Half Duplex Secondary Channel	L
Duplex Primary Channel* / Duplex Secondary Channel*	L
Duplex Primary Channel / Duplex Secondary Channel	M
Special (Circuits specified by Supplier)	Z

Note: Data Transmission Configurations identified with an asterisk (*) indicate the inclusion of Circuit CA (Request to Send) in a One Way Only (Transmit) or Duplex Configuration where it might ordinarily not be expected, but where it might be used to indicate a non-transmit mode to the data communication equipment to permit it to remove a line signal or to send synchronizing or traning signals as required.

Figure 5.1

Interface Types for Data Transmission Configurations

Interchange Circuit		Interface Type													
		A	B	C	D	E	F	G	H	I	J	K	L	M	Z
AA	Protective Ground	–	–	–	–	–	–	–	–	–	–	–	–	–	–
AB	Signal Ground	x	x	x	x	x	x	x	x	x	x	x	x	x	x
BA	Transmitted Data	x	x		x	x	x		x		x		x	x	o
BB	Received Data			x	x	x		x		x		x	x	x	o
CA	Request to Send		x		x		x				x		x		o
CB	Clear to Send	x	x		x	x	x		x		x		x	x	o
CC	Data Set Ready	x	x	x	x	x	x	x	x	x	x	x	x	x	o
CD	Data Terminal Ready	s	s	s	s	s	s	s	s	s	s	s	s	s	o
CE	Ring Indicator	s	s	s	s	s	s	s	s	s	s	s	s	s	o
CF	Received Line Signal Detector			x	x	x		x		x		x	x	x	o
CG	Signal Quality Detector														o
CH/CI	Data Signalling Rate Selector (DTE) /(DCE)														o
DA DB	Transmitter Sig. Element Timing (DTE) /(DCE)	t	t		t	t	t		t		t	t	t	t	o
DD	Receiver Signal Element Timing (DCE)			t	t	t		t		t		t	t	t	o
SBA	Secondary Transmitted Data							x		x	x	x	x	x	o
SBB	Secondary Received Data						x		x		x	x	x	x	o
SCA	Secondary Request to Send							x			x	x	x		o
SCB	Secondary Clear to Send							x		x	x	x	x	x	o
SCF	Secondary Received Line Signal Detector						x		x		x	x	x	x	o

Legend: ° - To be specified by the supplier
– - optional
s - Additional Interchange Circuits required for Switched Service
t - Additional Interchange Circuits required for Synchronous Channel
x - Basic Interchange Circuits. All Systems

Figure 5.2

Standard Interfaces For
Selected Communication Systems Configurations

SECTION SIX

6. RECOMMENDATIONS AND EXPLANATORY NOTES

6.1 The data are to be serialized by the data terminal equipment so that the design of the data communication equipment may be independent of the character length and code used by the data terminal equipment. The data communication equipment shall place no restrictions on the arrangement of the sequence of bits provided by the data terminal equipment.

6.2 The control interchange circuits at the interface point are arranged to permit the alternate use of a higher class of communication service as follows:

A. Data terminal equipment designed for Transmit-Only or Receive-Only service may also use either Half-duplex or Duplex service.

B. Data terminal equipment designed for Half-duplex service may also use Duplex service.

6.3 The electrical specifications are intended to provide a two-volt margin in rejecting noise introduced either on interchange circuits or by a difference in reference ground potential across the interface. The equipment designer should maintain this margin of safety on all interchange circuitry.

6.4 To avoid inducing voltage surges on interchange circuits. signals from interchange circuits should not be used to drive inductive devices, such as relay coils. (Note that relay or switch contacts may be used to generate signals on an interchange circuit, with appropriate measures to assure that signals so generated comply with Section 2.7.)

6.5 Alphabetical parenthetical designations are added to the terms used in Sections 2.3, 2.4, and 2.6 to better tie them in with the equivalent circuit of Section 2.1 and stress the point that the 2500 picofarad capacitance (C_L) is defined for the receiving end of the interchange circuit and that the capacitance (C_O) at the driving end of the interchange circuit, including cable, is not defined. It is the responsibility of the designer to build a circuit capable of driving all of the capacitance in the driver circuitry plus the capacitance in his part of the interconnecting cable (not specified) plus 2500 pF in the load (including the cable on the load side of the interface point).

6.6 The user is reminded that the characteristics of an equivalent load (terminator) circuit used to test for compliance with each of the electrical specifications in section 2 are a function not only of the parameter under test, but also of the tolerance limit to be tested. For example. a driver which just delivers a minimum of 5 Volts into a 7,000 Ohm test load may fail the test if the load is reduced to 3.000 Ohms, whereas, a driver with an output within the 15 Volt limit when driving a 3,000 Ohm load may exceed this limit when driving a 7,000 Ohm load. The 5 Volt tolerance should therefore be tested with a 3,000 Ohm load while the 15 Volt limit should be tested using a 7,000 Ohm load.

6.7 The operation of the transmitting and receiving circuits should minimize the effects of any circuit time constants which would delay the circuit response and introduce time distortion of the signals.

6.8 The turning ON of Circuit CA (Request to Send) does not necessarily imply the turning ON of a line signal on the communication channel. Some data sets might not have a line signal as it is understood in this standard, e.g. the signal can be a modified digital base-band signal.

Conversely, in data sets which do transmit a "line signal", the turning OFF of Circuit CA does not necessarily command the removal of that line signal from the communication channel. On a duplex channel, the data set might autonomously transmit a training signal to hold AGC Circuits or automatic equalizers in adjustment, or to keep timing locked (synchronized) when Circuit CA is OFF.

It is not within the scope of this standard to specify in detail what occurs on the communication channel (line) side of the data communication equipment. Therefore the definition for Circuit CA uses the terminology "assume the transmit mode" intentionally avoiding reference to "carrier" or "line signals".

However, the continued requirement for multipoint systems is recognized. Data sets intended for this type of operation should permit the sharing of a communication channel by more than one data set transmitter and should, when in a non-transmit mode, place no signal on the communication channel which might interfere with the transmission from another data set in the network.

6.9 It is important that, at an answering data station, Circuit CC (Data Set Ready) be turned ON independently of any event which might occur at the remote (calling) data station. This independence permits the use of the OFF to ON transition of Circuit CC to start an "abort timer" in the data terminal equipment. This timer would cause termination of an automatically answered call (by causing Circuit CD to be turned OFF) if other expected events such as Circuit CF ON or proper exchange of data do not occur in a predetermined time interval. Such independence is necessary to assure the starting of the abort timer when an automatically answered incoming call is the result of a wrong number reached from a regular (non data station) telephone instrument.

6.10 Although the method of operation for multi-line automatic calling equipment, RS-366 (when assigned) Interface Type V, has not yet been fully defined, it appears that a situation could arise during call origination where both the DCE and the ACE appear to be idle (at the interface) even though actively engaged in establishing a connection.

One possible solution to this problem requires that circuit CC be turned ON upon completion of dialing to provide continuity of signalling during call origination. When multiline automatic calling equipment is used, Circuit CC would thus turn ON earlier than specified in Section 4.4 herein. This solution is subject to further study; however, data terminal equipment which may, in the future, be used in systems with multi-line automatic calling equipment should not be adversely affected by this early "Data Set Ready" indication.

SECTION SEVEN

7. GLOSSARY OF NEW TERMS

7.1 This section defines terms used in this standard which are new or are used in a special sense.

1. Data Transmission Channel

The transmission media and intervening equipment involved in the transfer of information between data terminal equipments. A data transmission channel includes the signal conversion equipment. A data transmission channel may support the transfer of information in one direction only, in either direction alternately, or in both directions simultaneously and the channel is accordingly classified as defined in the following sections. When the data communications equipment has more than one speed capability associated with it, for example 1200 baud transmission in one direction and 150 baud transmission in the opposite direction, a channel is defined for each speed capability.

2. Primary Channel

The data transmission channel having the highest signaling rate capability of all the channels sharing a common interface connector. A primary channel may support the transfer of information in one direction only, either direction alternately or both directions simultaneously and is then classified as "one way only", "half duplex" or "duplex" as defined herein.

3. Secondary Channel

The data transmission channel having a lower signaling rate capability than the primary channel in a system in which two channels share a common interface connector. A secondary channel may be either one way only, half duplex or duplex as defined later. Two classes of secondary channels are defined, auxiliary and backward.

4. Auxiliary Channel

A secondary channel whose direction of transmission is independent of the primary channel and is controlled by an appropriate set of secondary control interchange circuits.

5. Backward Channel

A secondary channel whose direction of transmission is constrained to be always opposite to that of the primary channel. The direction of transmission of the backward channel is restricted by the control interchange circuit (Circuit CA – Request to Send) that controls the direction of transmission of the primary channel.

6. One Way Only (Unidirectional) Channel

A primary or secondary channel capable of operation in only one direction. The direction is fixed and cannot be reversed. The term "one way only" used to describe a primary channel